b) Alternator Dynamic Test Data Set

DELPHI Automotive Systems

Ron J Kretta

03/20/2000 09:10:02 AM

To: Mike D. Bradfield@US_GM_AND_P1801@EDS HUB
cc: John A MacBain/DELCO@DELCO

Subject: Re: Gebamo and the Scenic

Mike,

I have reviewed the winding of the Renault Scenic generator. The data indicates the machine was wound with 19 conductors per slot of 1 strand of 16.5 AWG (2/#16.5). The data which you have provided GEBAMO constants around was likely based upon a 9 conductor per slot 2/#16. When scaled up to 42 volt, you assumed a winding of 3*9 or 27 conductors per slot 1/#17.75.

I believe the difference in conductors per slot is the likely culprit in the difference in performance between us. Why the winding was chosen as it was is a mystery to me. Mel Halmann originally spec'ed this winding. Perhaps he intended to connect it in wye and get 33 conductors per slot to try to increase the idle power. To the best of my knowledge this generator is connected in delta.

Test data we have from Lux indicates stabilized 25 deg C performance as

RPM	Igen	Vdc	Ifld
1500	7.1	40.71	4.7
1800	22.9	40.82	4.7
3000	48.3	40.98	4.7
6000	59.4	41.06	4.8
10000	61.7	41.07	4.9

Let me know if this winding issue is real and makes sense to you as the source of our confusion.
rjk

03/20/2000 08:19:12 AM

---------- Forwarded by John A MacBain/DELCO on 03/20/2000 08:18 AM ----------

Mike D. Bradfield@US_GM_AND_P1801 on 03/17/2000 04:28:40 PM

To: John A MacBain

John,

The GEBAMO constants I have sent you are based on projected 42 volt performance of an AD237 which has had the stator 'rewound' to operate at 42V conditions. To accomplish this I take physical 14V, 12.8 data and then divide the output current by the ratio (14/42), or 3. This gives a constant power output for the machine at 14 and 42V . . .

Mike

From: John A MacBain@DELCO on 03/17/2000 04:14 PM

From: John A MacBain@DELCO on 03/17/2000 04:14 PM

To: *Mike D. Bradfield@US_GM_AND_P1801@EDS* HUB
cc: Ron J. Krefta/DELCO@DELCO
Subject: Re: Gebamo and the Scenic

Mike,

I appreciate that you addressed this problem for me. Unfortunately, I do not think we have yet had closure - or, at least, I still have confusion. The most recent (some time back) run from ron Krefta modeled the situation much like the Scenic where the output current all went to the 42V bus without withdrawing the field current.

The values he supplied me do not agree with your values. He has supplied the following currents with a 4.9 A field current into an ideal 42V source at the output of the rectifier:

1600	18.88
1800	28.3
2000	34.4
2500	43.16
3000	47.21
3500	49.33
4000	50.53
5000	51.67
6500	52.42
8000	52.72

I guess I need to understand why the wide differential from your results, both Gebamo and experimental.

My 3phase modeling of Ron's results matched very nicely - my simulated result to his design program.

Can we schedule a time to talk together on Monday? I would like to get Ron on the call as well.

Thanks again!!!

John

Mike D. Bradfield@US_GM_AND_P1801 on 03/17/2000 03:22:39 PM

Mike D. Bradfield@US_GM_AND_P1801 on 03/17/2000 03:22:39 PM

To: John A MacBain

John,

I took a second look at the material I put together for you on the GEBAMO constants back in September.

---------- Delphi Energy & Engine Management Systems Proprietary Data ----------
---------- (2/29/2000) ---- (16:11:22) ---------- Version: 1.0 ----------

INPUT DATA

Units ? Units Units inches

STATOR INPUT DATA

OD	5.4180	----	STATOR OUTER DIAMETER
ID	4.1710	----	STATOR INNTER DIAMETER
SLS	1.3020	----	STATOR STACK LENGTH
DBS	0.1800	----	STATOR YOKE DEPTH
SFL	0.9000	----	STACKING FACTOR
SL	36.0000	----	NUMBER OF SLOTS
H1	0.0000	----	STATOR SLOT DIMENSION
H2	0.0194	----	STATOR SLOT DIMENSION
H3	0.0200	----	STATOR SLOT DIMENSION
BO	0.0996	----	STATOR SLOT OPENING
STW	0.1661	----	STATOR TOOTH WIDTH
SLTINS	0.0150	----	SLOT INSULATION WIDTH
G1	0.0140	----	MAIN AIR GAP LENGTH
SAWG	16.5000	----	WIRE GAGE OF ARMATURE WINDING WIRE
VDC	42.0000	----	RATED OUTPUT VOLTAGE
TC	19.0000	----	NUMBER OF TURNS PER COIL
ESC	0.0700	----	ARMATURE WINDING EXTENSION BEYOND STACK
RSC	0.2000	----	ARMATURE WINDING RADIUS BEYOND STACK
DELTA	1.0000	----	DELTA CONNECTION = 1 / WYE CONNECTION = 0

ROTOR INPUT DATA

TED	0.5354	----	ROTOR END DISK THICKNESS
DC	2.2320	----	ROTOR CORE DIAMETER
CL	1.1150	----	ROTOR CORE LENGTH
GLP	1.0560	----	LENGTH OF ROTOR POLE
CID	2.3380	----	FIELD COIL DIAMETER
COILW	1.0050	----	FIELD COIL WIDTH
WPT	0.3040	----	ROTOR TOOTH WIDTH AT TIP OF TOOTH
WPR	1.0200	----	ROTOR TOOTH WIDTH AT ROOT OF TOOTH
HPT	0.1300	----	ROTOR TOOTH HEIGHT AT TIP OF TOOTH
HPR	0.5210	----	ROTOR TOOTH HEIGHT AT ROOT OF TOOTH
TRAD	0.0315	----	ROTOR TOOTH BEND RADIUS
G2	0.0001	----	ROTOR AIR GAP LENGTH BETWEEN CORE AND END DISK
RP	12.0000	----	NUMBER OF POLES
TRC	315.0000	----	FIELD WINDING NUMBER OF TURNS
RAWG	19.4500		WIRE GAGE OF FIELD WINDING
TFLD	110.0000	----	ROT FIELD TEMPERATURE
TA	110.0000	----	AMBIENT TEMPRRATURE
VFLD	12.0000	----	DC VOLTAGE APPLIED TO FIELD WINDING

PMW	0.0000	----	PERMANENT MAGNET WIDTH
PMH	0.0000	----	PERMANENT MAGNET HEIGHT
PML	0.0000	----	PERMANENT MAGNET LENGTH
PMC	0.00	----	PERMANENT MAGNET Hc (AT/IN)
PMB	0.00	----	PERMANENT MAGNET Br (KLINES/IN**2)

MACHINE WEIGHTS (LBS)

WSTT	----	0.6796	---- WEIGHT STATOR TEETH
WSTY	----	0.9852	---- WEIGHT STATOR YOKE
TOWST	----	1.66	---- TOTAL STATOR CORE WEIGHT
WRSEG	----	3.6078	---- WEIGHT ROTOR SEGMENT
WRCO	----	1.2380	---- WEIGHT ROTOR COIL
WPM	----	0.0000	---- WEIGHT ROTOR MAGNETS
TOWRO	----	4.85	---- TOTAL ROTOR MAG WEIGHT
TOWFE	----	6.7115	---- TOTAL IRON WEIGHT
WSCU	----	1.1456	---- STATOR WINDING WEIGHT
WRCU	----	0.7858	---- ROTOR FIELD COIL WEIGHT
TOWCU	----	1.93	---- TOTAL COPPER WEIGHT
TOTALW	----	8.64	---- TOTAL ELECTRICAL WEIGHT

Units

lb

C°

DATA FOR LOAD CASE CALCULATIONS

N1 ---- 10 ---- NUMBER OF POINTS FOR LOAD PERFORMANCE

ALTERNATOR SPEED	STATOR WINDING TEMP.	FIELD CURRENT
RPM(1) = 1600.0	TS(1) = 154.00	FLDA(1) = 4.90
RPM(2) = 1800.0	TS(2) = 180.00	FLDA(2) = 4.90
RPM(3) = 2000.0	TS(3) = 202.00	FLDA(3) = 4.90
RPM(4) = 2500.0	TS(4) = 223.00	FLDA(4) = 4.90
RPM(5) = 3000.0	TS(5) = 237.00	FLDA(5) = 4.90
RPM(6) = 3500.0	TS(6) = 220.00	FLDA(6) = 4.90
RPM(7) = 4000.0	TS(7) = 208.00	FLDA(7) = 4.90
RPM(8) = 5000.0	TS(8) = 191.00	FLDA(8) = 4.90
RPM(9) = 6500.0	TS(9) = 173.00	FLDA(9) = 4.90
RPM(10) = 8000.0	TS(10) = 162.00	FLDA(10) = 4.90

DATA FOR OPEN CIRCUIT VOLTAGE CALCULATION

N2 --- 9 ---- NUMBER OF POINTS
XMFS ---- 1600.0 ---- ALTERNATOR SPEED

FIELD CURRENT

FLDX (1) = 0.10
FLDX (2) = 0.50
FLDX (3) = 1.00
FLDX (4) = 2.00
FLDX (5) = 3.00
FLDX (6) = 4.00
FLDX (7) = 4.90
FLDX (8) = 5.00
FLDX (9) = 6.00

1

OUTPUT DATA

ARMATURE WINDING

SLOTFF	0.4620		SLOT FILL FACTOR
TSP	114.0000		NUMBER OF TURNS PER PHASE
ASC	0.0018		CROSS SECTIONAL AREA OF ARMATURE WINDING WIRE
RMTL	5.7766		MEAN LENGTH OF ARMATURE WINDING TURN
RS80	0.2543		PHASE WINDING RESISTANCE @ 80 DEGREES F.

FIELD WINDING

SLOTFF	0.7599		SLOT FILL FACTOR
RWL	11.2564		NUMBER OF LAYERS OF WIRE IN FIELD COIL
CPL	27.9842		NUMBER OF TURNS PER LAYER
ARC	0.0009		CROSS SECTIONAL AREA OF FIELD WINDING WIRE
RMTL	8.5261		MEAN LENGTH OF FIELD WINDING TURN
RF80	2.0052		FIELD WINDING RESISTANCE @ 80 DEGREES F.

o/o

inches
Units
in^2

--- OPEN CIRCUIT VOLTAGE @ SPEED = 1600.0 RPM ---

I_FIELD	EMF	FLUX_GAP	FLUX_PE	LOSS	FRICTION	WINDAGE
0.100	1.454	2.304	1.935	0.21	16.10	0.89
0.500	7.758	13.005	10.321	6.87	16.10	0.89
1.000	15.790	26.460	21.006	28.47	16.10	0.89
2.000	28.693	48.640	38.171	93.97	16.10	0.89
3.000	34.422	60.207	45.865	135.67	16.10	0.89
4.000	36.905	66.139	49.095	155.46	16.10	0.89
4.500	38.153	69.601	50.756	166.15	16.10	0.89
5.000	38.263	69.928	50.902	167.11	16.10	0.89
6.000	39.121	72.713	52.043	174.68	16.10	0.89

NI_T1	NI_Y1	NI_T2	NI_End	NI_dsk	NI_chk	NI_Y2	NI_gap	NI_tot
0.2	0.2	0.7	0.5	0.4	0.1	1.1	12.6	15.7
0.5	0.4	2.6	2.0	1.4	0.2	4.2	67.3	78.7
1.1	0.8	4.9	3.6	2.4	0.4	7.4	137.0	157.5
11.2	4.2	21.9	12.5	5.6	1.0	19.6	249.0	315.0
41.5	12.3	32.2	41.4	10.1	2.4	43.0	299.2	472.5
65.4	20.8	33.9	88.8	15.2	4.9	80.5	320.4	630.0
79.7	27.3	44.3	111.4	20.9	8.0	129.0	331.3	771.7
81.2	28.0	45.3	136.1	21.9	8.4	154.9	332.2	787.8
92.8	34.0	57.3	185.2	28.5	12.1	195.3	339.7	945.0

use this actual

--------- Delphi Energy & Engine Management Systems Proprietary Data ---------
---------- Load Point Data ----------

	Ld Pnt 1	Ld Pnt 2	Ld Pnt 3	Ld Pnt 4	Ld Pnt 5	Ld Pnt 6
RPM	1600.00	1800.00	2000.00	2500.00	3000.00	3500.00
Field Current	4.90	4.90	4.90	4.90	4.90	4.90
DC Current	31.57	31.74	38.22	47.49	51.79	54.01
DC Voltage	42.00	42.00	42.00	42.00	42.00	42.00
Elect Power	905.94	1333.03	1605.21	1994.69	2175.26	2268.60
Shaft Power	1198.24	1764.56	2187.47	2759.67	3059.06	3218.11
Efficiency	75.61	75.54	74.40	72.28	71.11	70.49
Shaft Torque	7.15	9.36	10.30	10.54	9.74	8.70
Phase Current	9.41	13.88	16.72	20.77	22.65	23.63
Phase Voltage	33.32	33.39	33.42	33.47	33.49	33.50
Line Current	16.34	24.04	28.95	35.98	39.24	40.92
Line Voltage	33.32	33.39	33.42	33.47	33.49	33.50
Airgap EMF	36.47	38.64	40.46	44.16	47.38	50.30
Field EMF	38.81	47.51	56.00	80.16	105.38	129.89
Eq-I angle	8.22	12.90	16.58	23.96	29.76	34.67

Vac-I angle	0.00	0.00	0.00	0.00	0.00	0.00
Ef-I angle	24.95	37.56	46.18	59.78	69.08	71.47
Stator Res	0.2939	0.3080	0.3204	0.3312	0.3334	0.3296
Leakage React	0.5525	0.6215	0.6906	0.8633	1.0359	1.3065
Sync React	1.7797	2.0862	2.4171	3.3346	4.2846	5.2127
Losses ...						
Stat Cu Loss	78.48	178.04	268.60	426.74	513.28	551.95
Fld Cu Loss	52.43	52.43	52.43	52.43	52.43	52.43
Diode Loss	37.18	57.50	70.95	91.27	100.93	105.85
Stray Loss	7.85	17.80	26.86	42.87	51.32	55.10
Eddy Cur Loss	58.96	66.19	72.52	86.44	99.09	111.71
Hyst Loss	92.84	92.64	91.42	87.13	83.22	80.42
Frict Loss	16.10	18.11	20.12	25.15	30.18	35.22
Windage Loss	0.89	1.26	1.73	3.38	5.85	9.29
Fluxes ...						
Air Gap Flux	48.515358	45.691292	43.060081	37.595627	33.544651	30.527836
Rot Tth Flux	62.230133	61.127628	59.920147	56.813667	53.789188	51.182659
Rot Bend Flux	69.254677	68.585188	67.706740	65.070366	62.175205	59.600605
Stat Tooth B	130.5132	122.9160	115.8777	102.1376	90.2399	82.1242
Stat Yoke B	115.0067	108.3122	102.0749	89.1213	78.5183	72.3669
Rotor Tooth B	97.6695	96.4957	95.0793	91.0657	86.7985	82.9866
Rotor Band B	115.5054	123.6590	111.2178	105.4519	99.8381	95.0001
Rotor Disk B	96.3702	95.4389	94.2190	90.5476	86.5189	82.9363
Rotor Core B	106.1995	105.2731	103.8288	99.7830	95.3424	91.3963
Ampere Turns ...						
Field NI	771.79	771.79	771.79	771.79	771.79	771.79
Stat Tooth NI	61.04	40.82	26.84	10.04	4.94	3.23
Stat Yoke NI	18.91	11.98	8.00	3.93	2.37	1.66
Rot Tooth NI	42.24	39.13	35.67	27.46	22.20	18.73
Rot Band NI	117.10	98.68	82.16	49.60	30.24	22.06
Rot Disk NI	20.22	19.03	17.57	13.83	11.43	9.74
Rot Choke NI	7.64	6.96	6.16	4.25	2.97	2.28
Rot Yoke NI	123.10	112.37	99.73	69.98	52.39	40.49
Core Gap NI	2.93	2.94	2.88	2.73	2.59	2.46
Airgap NI	313.46	295.22	278.22	242.91	216.74	199.34
Stator NI eff	94.68	201.33	286.96	427.05	496.42	532.95

..... Delphi Energy & Engine Management Systems Proprietary Data .....
..... Load Point Data .....

	Ld Pnt 7	Ld Pnt 8	Ld Pnt 9	Ld Pnt 10	Ld Pnt
RPM	6000.00	6000.00	6500.00	8000.00	
Field Current	4.90	4.90	4.90	4.90	
DC Current	55.30	56.50	57.28	57.60	
DC Voltage	42.00	42.00	42.00	42.00	
Elect Power	2322.56	2373.16	2405.80	2419.15	
Shaft Power	3313.14	3429.63	3570.54	3739.53	
Efficiency	70.10	69.20	67.34	64.86	
Shaft Torque	7.91	6.55	5.25	4.45	
Phase Current	34.19	34.71	35.05	35.19	
Phase Voltage	33.51	33.51	33.51	33.52	
Line Current	41.89	42.81	43.39	43.64	
Line Voltage	33.51	33.51	33.51	33.57	
Airgap RMF	59.16	59.36	69.67	80.79	
Field RMF	159.60	197.51	261.23	323.20	
Eg-I angle	38.95	45.96	53.81	59.48	
Vac-I angle	0.00	0.00	0.00	0.00	
Ef-I angle	74.39	77.94	80.94	82.71	
Stator Res	0.3231	0.3139	0.3042	0.2982	
Leakage React	1.3012	1.7265	2.2444	2.7624	
Sync React	6.1163	7.8152	10.3008	12.7286	
Losses ...					

give this
Setup
60.0A

Stat Cu Loss	567.04	575.19	572.80	567.86
Fld Cu Loss	52.43	52.43	52.43	52.43
Diode Loss	108.72	111.43	113.18	113.90
Stray Loss	56.70	57.52	57.26	56.79
Eddy Cur Loss	125.17	156.21	215.19	289.32
Hyst Loss	78.94	78.79	83.41	91.12
Frict Loss	40.25	50.31	65.40	80.49
Windage Loss	13.86	27.09	59.46	110.89
Fluxes ...				
Air Gap Flux	28.275032	25.269957	22.814600	21.494177
Rot Tth Flux	49.086578	46.089676	43.557007	42.156822
Rot Bend Flux	57.485266	54.423690	51.813786	50.362936
Stat Tooth B	76.0638	69.9798	61.3745	57.8224
Stat Yoke B	67.0266	59.9030	54.0825	50.9524
Rotor Tooth B	79.9721	75.3579	71.5192	69.3864
Rotor Bend B	91.1096	85.5471	80.8462	78.2473
Rotor Disk B	79.9927	75.7299	72.1006	70.0817
Rotor Core B	88.1515	83.4539	79.4545	77.2297
Ampere Turns ...				
Field NI	771.79	771.79	771.79	771.79
Stat Tooth NI	2.40	1.67	1.26	1.12
Stat Yoke NI	1.30	0.96	0.84	0.78
Rot Tooth NI	16.32	13.97	12.28	11.39
Rot Bend NI	17.11	13.05	10.58	9.59
Rot Disk NI	8.54	7.37	6.50	6.07
Rot Choke NI	1.84	1.46	1.22	1.11
Rot Yoke NI	34.04	27.60	23.22	21.50
Core Gap NI	2.36	2.22	2.09	2.03
Airgap NI	182.69	163.27	147.41	138.88
Stator NI-eff	554.26	575.04	588.67	594.56